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Case Report

A different and simple 3D planning process for stenting a ductus in a patient with truncus arteriosus

3D planning for stenting a ductus in a newborn

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Abstract
Three-dimensional (3D) modeling is very useful and effective for surgical management, but it is also an expensive method. After 3D cardiac modeling was completed for our patient, a successful ductal stent intervention was performed. In this case report, a new 3D approach was used to improve the success of ductal stent intervention on a neonate with truncus arteriosus.
Our aim is to show that 3D modeling can aid in medical follow-up, angiographic, and/or surgical intervention decisions in congenital heart disease patients with difficult congenital heart disease.

Keywords
Truncus Arteriosus, 3D PDF, Ductal Stenting

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Introduction

Truncus arteriosus is a rare cardiac anomaly that constitutes 1-4% of all congenital heart diseases [1]. It is characterized by a single arterial vessel originating from the ventricular region of the heart, sitting onto the ventricular septum and giving branches to the systemic pulmonary and coronary circulation [2]. In the early period, surgical or transcatheter intervention saves lives and it is highly important to define the anatomy in the preoperative period.

CT angiography and 3D printing are two techniques that are commonly used to define cardiac anatomy. However, due to the high cost of 3D printing and the fact that CT images can only be viewed on radiology workstations or with special software, alternative methods have been developed. Based on our clinical experience, we believe that 3D PDFs can assist clinicians in providing affordable and effective solutions at this time. The stenting of a newborn with truncus arteriosus utilizing 3D PDF is the topic of this article.

Case Report

Echocardiography of the infant indicated the diagnosis of truncus arteriosus, and prostaglandin treatment was initiated. At birth, his oxygen (O2) saturation in room air was 78%.

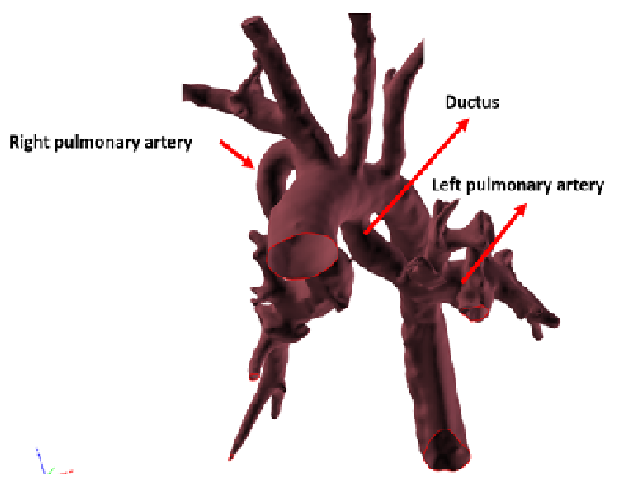

Figure 1. 3D visualization of the aortic arch with a single cross-section from 3D PDF

The CT angiographic examination was performed on the first postnatal day. It was reported that the left pulmonary artery showed continuity with patent ductus arteriosus (PDA), whereas the right pulmonary artery was filled with collateral vascular structure diverting from the brachiocephalic trunk (Figure 1).

It was planned to apply a ductal stent to avoid the side effects of the prostaglandin infusion required to support the left lung and protect the patient from prostaglandin dependence. To show the anatomy more clearly and conduct a detailed assessment of the ductal stent plan before the procedure, the CT images were reformatted as a 3D PDF. Within the scope of this study, a 3D planning and modeling process was made using the Mimics Innovation Suite 22.0 (Ma¬terialize, Leuven, Belgium) software. The technique of this procedure was defined in our previous report [3]. In this way, we were able to analyze cardiac images in detail and interactively, regardless of the CT platform. The blood vessels diverging from the truncal arch and reaching the lung were interactively analyzed in detail with their routes and lumen structures using the 3D PDF document that was prepared. On the 3D PDF document, the anatomy of the ductus arteriosus was clearly portrayed, and the size of the ductus arteriosus was measured at 3.38 mm (Figure 2 a,b). The information from the 3D PDF was crucial for the interventional process.

On the fifth day after birth, stent application was performed on the vertical ductus of the patient with an atypical localization and showed continuity with the left pulmonary artery. No complication was encountered during or after the procedure. After the procedure, due to the possible risk of thrombosis, prophylactic enoxaparin sodium and aspirin treatment was started. Echocardiography showed a well-positioned stent and patent flow through the stent. Prostaglandin treatment was ceased, and the oxygen saturation levels of the patient who did not receive prostaglandin during the monitoring period were 80-85%. Thrombosis was observed in the stent at the 36th hour of monitoring, and for this reason, tissue plasminogen activator (TPA) treatment was started. At the 6th hour of the TPA treatment, it was seen in the echocardiographic examination that the stent flow was laminar. The stent was thrombosed, and the blood flow inside the lumen was reduced according to an echocardiographic study performed 12 hours after the TPA treatment was completed. During the monitoring period,

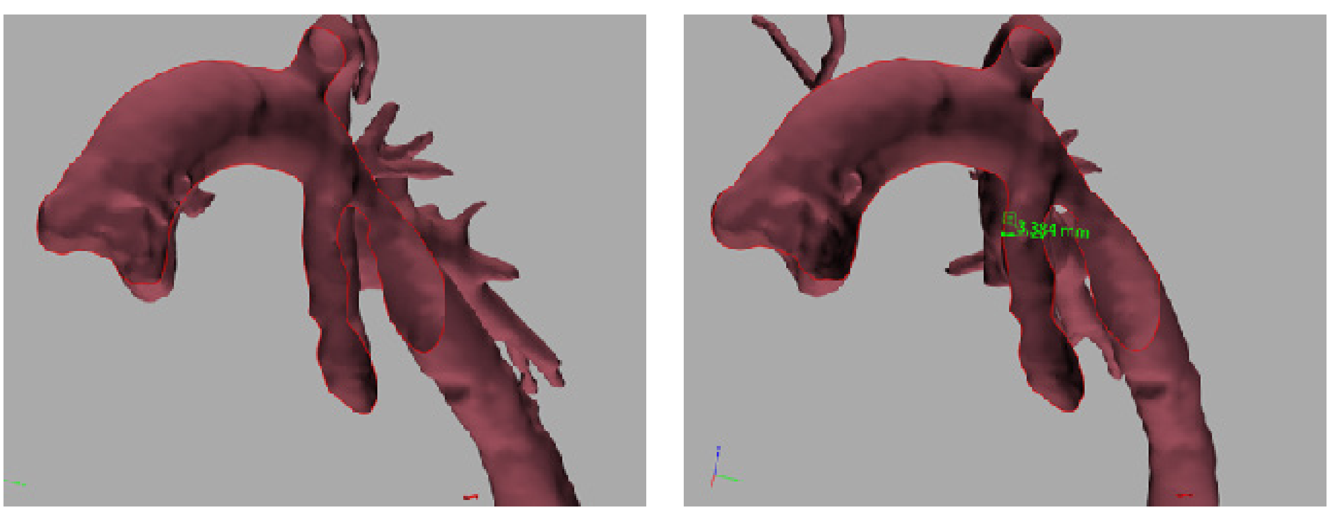

Figure 2. (a) The anatomy of the ductus arteriosus (b) the size of the ductus arteriosus

the patient's O2 saturation levels remained between 60% and 70%. However, due to prolonged hypoxia and complications, the patient died on the 18th postnatal day.

Discussion

Three-dimensional visualization has allowed a better understanding of the relationships among cardiac structures and opened new horizons in the treatment of patients with congenital heart diseases [4]. The importance of 3D print materials is also getting higher day by day in determining the strategy before the procedure in cardiac surgery and interventional cardiology. Valverde et al. (2017) investigated the effects of 3D-printed models in 40 patients who were scheduled for complex congenital cardiac surgery and observed that these models created differences in the surgical method in 19 patients [5]. 3D modeling was performed for a case with partial anomalous pulmonary venous return and sinus venosus type ASD before the intervention. 3D models demonstrated that placing the stent into the superior vena cava towards the right atrium would close the sinus venosus type defect. This way, by showing that it is possible to direct the pulmonary venous flow towards the left atrium, the procedure was implemented through the transcatheter route [4,6]. However, the costs of 3D modelling and printing processes are high. Therefore, as an alternative method that provides an opportunity for an examination as detailed as 3D-printed models, 3D PDF may provide great advantages before surgery and invasive interventional procedures [7].

The portable document format (PDF) is a de facto standard in the use of electronic documents today. A PDF file contains the data required for reconstructing 3D models without the need for an additional source. Additionally, 3D PDF has many advantages when compared to 3D CT images. Adobe Reader allows the user to accurately view 3D models and use options, such as zooming, scrolling, rotating or selecting relevant parts and exporting sections from the desired part. It works compatibly with all operating systems that are most prevalently used around the world (MS Windows, Mac OS, Linux) [8]. Thus, any scenario can be tested on 3D PDF, and data exchange is possible between computers running different operating systems. Using 3D PDF does not require any additional specialized hardware or software. Also, in terms of data size, 3D PDF files require much less storage space than other 3D materials. Such factors provide all clinicians and medical students with the opportunity to easily benefit from 3D PDF. Due to these advantages, 3D PDF has been used at our clinic for a long time [3]. To implement the stent successfully, it is important to define the ductal anatomy well before the procedure.

Conclusion

For imaging congenital cardiac abnormalities, CT angiography and 3D printing are commonly utilized procedures. Nevertheless, as the cost of 3D prints is high, and CT images can only be examined at radiology workstations or with specialized software, the need for using alternative methods has emerged. As in the case in our study, based on our clinical experience, it is thought that 3D PDF may help clinicians in the process of providing inexpensive and effective solutions.

Scientific Responsibility Statement
The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement
All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

Conflict of interest
None of the authors received any type of financial support that could be considered potential conflict of interest regarding the manuscript or its submission.

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